Los Angeles Pilot Project Using Japanese Earthquake Resistant Joint Ductile Iron Pipe

Los Angeles Department of Water & Power
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California-Nevada Section
American Water Works Association
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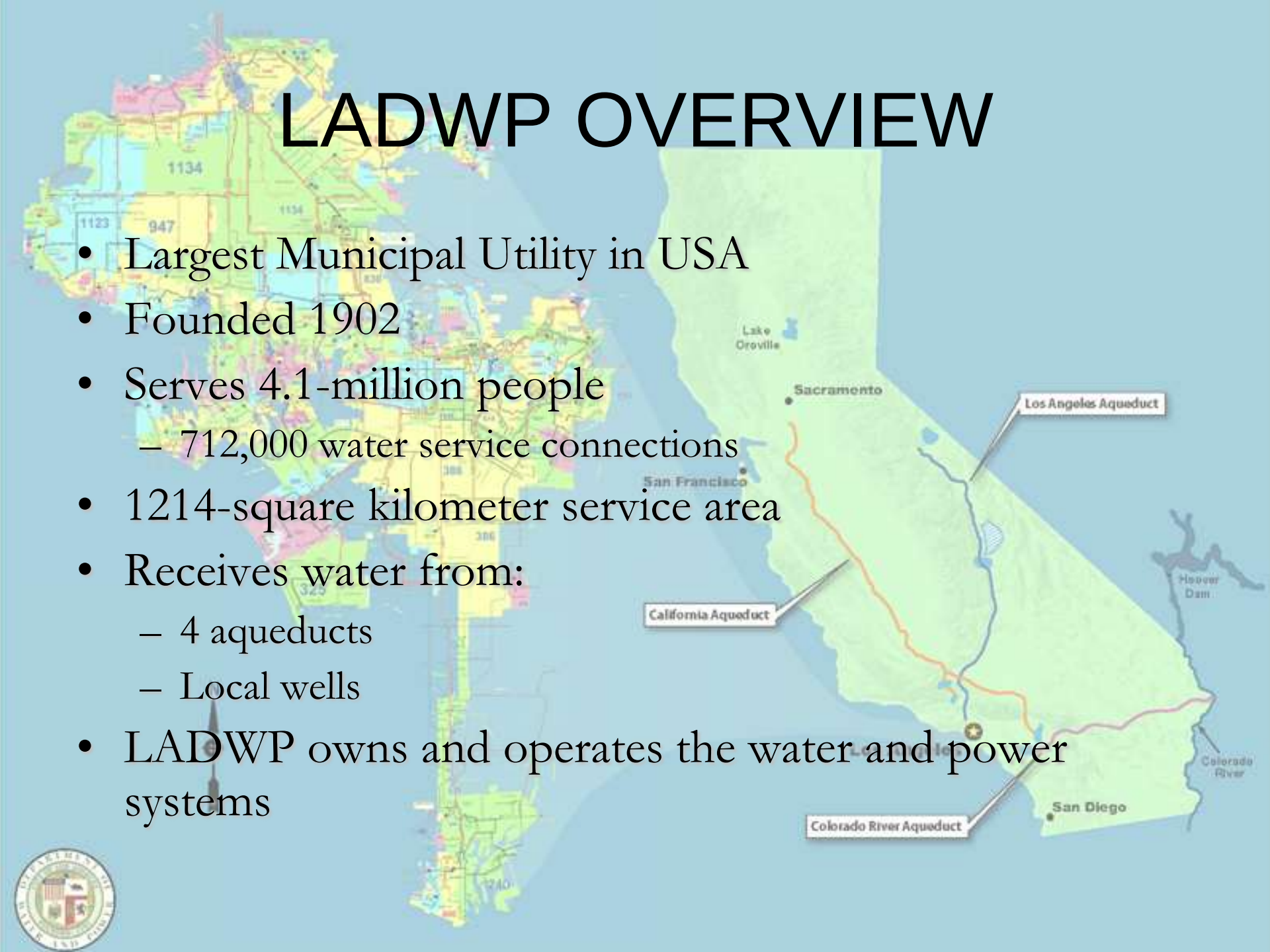
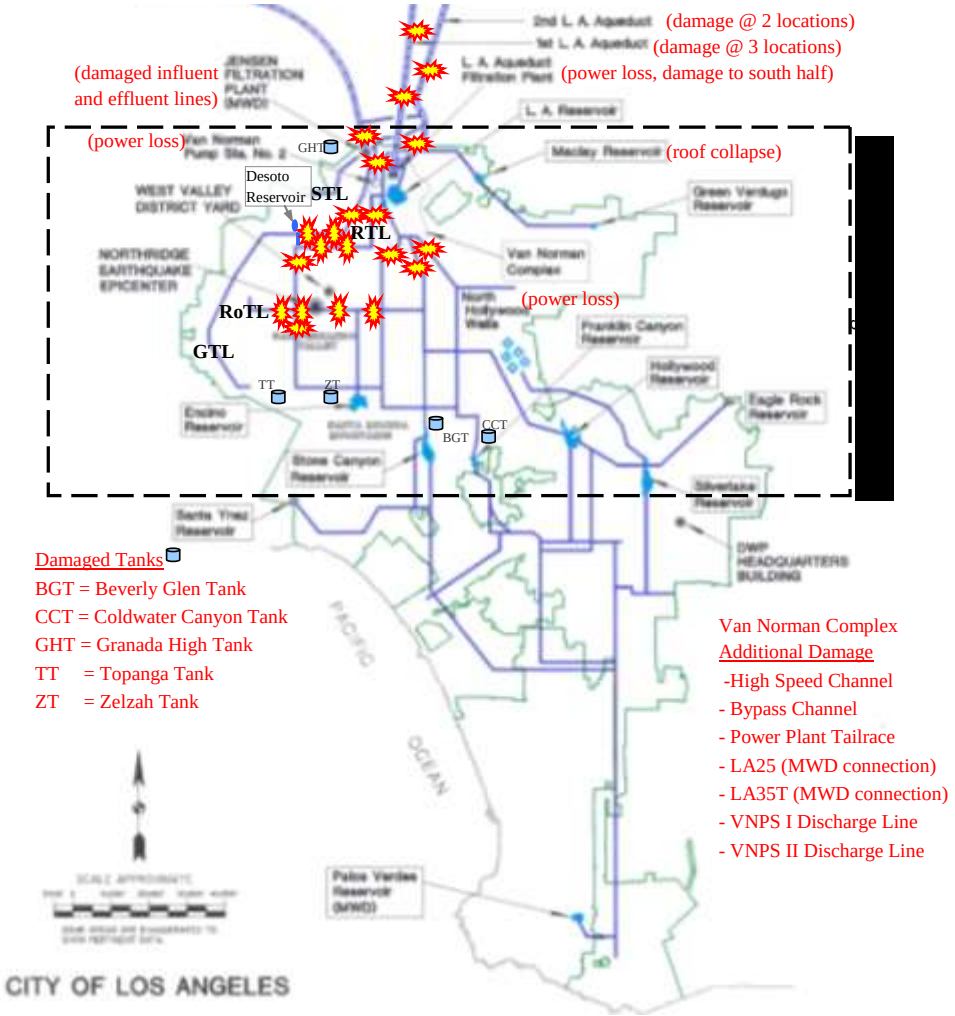
LADWP OVERVIEW

- Largest Municipal Utility in USA
- Founded 1902
- Serves 4.1-million people
  - 712,000 water service connections
- 1214-square kilometer service area
- Receives water from:
  - 4 aqueducts
  - Local wells
- LADWP owns and operates the water and power systems



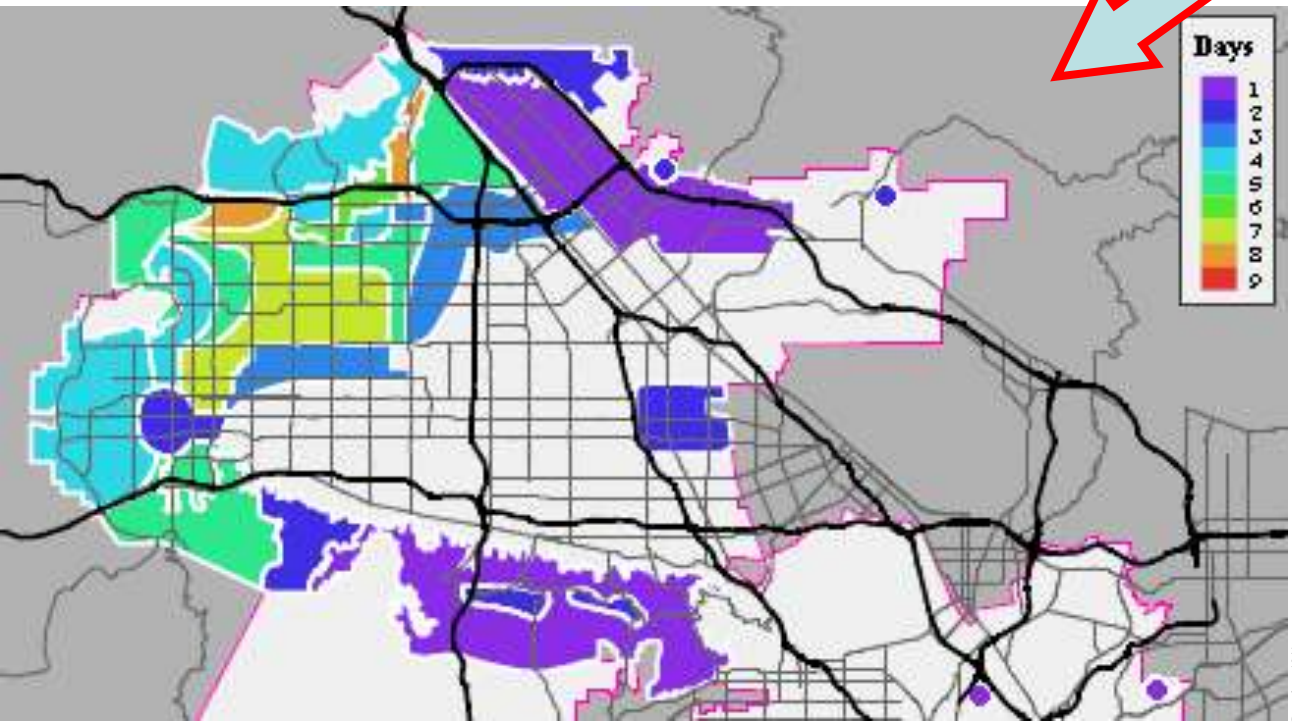
Water System Performance in 1994 Northridge Earthquake

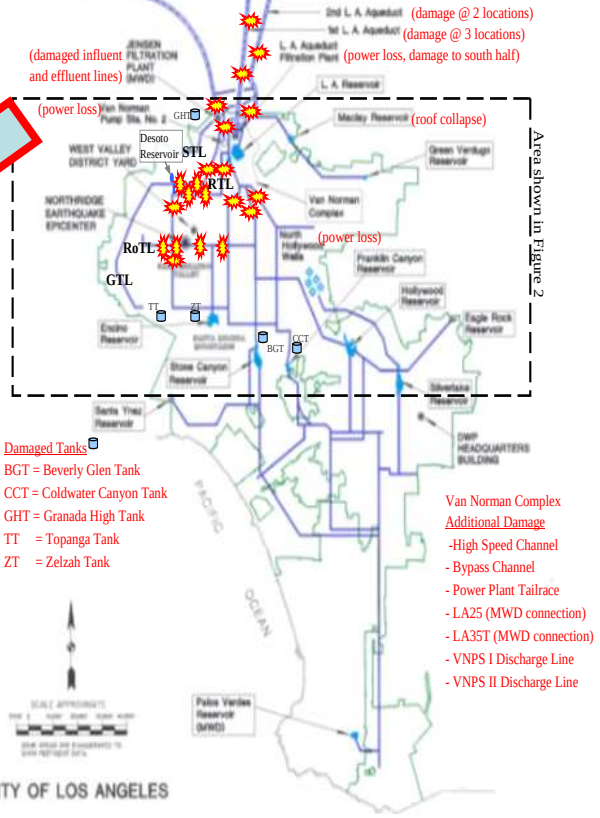


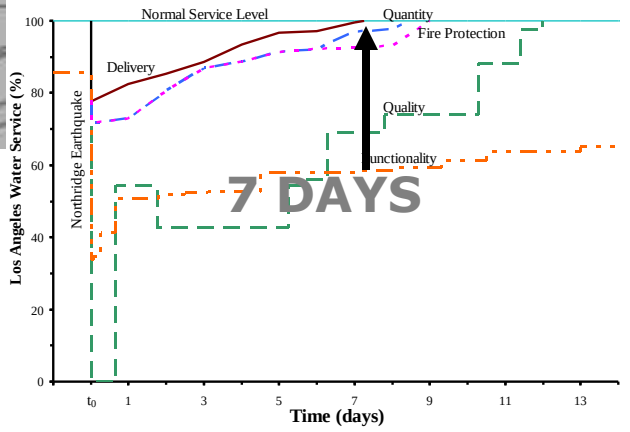
Los Angeles water supply and transmission subsystems showing major facilities and 1994 damages

- **<u>Water System Damages</u>**
- 14 repairs to the raw water supply conduits
- 60+ repairs to treated water transmission pipes
- 1013 repairs to distribution pipe
- > 200 service connection repairs
- 7 damaged tanks
- Temporary suspension of half the treatment plant service
- Power lost throughout City
- $41 million total repair costs

1994 L.A. DELIVERY SERVICES







- 159,434 service connection outages
- 22% of all services
- ~670,000 residents
- All delivery service restored in 7 days
- Pipe repairs completed several weeks later

Network Resilience by Incorporating Seismic Resistant Distribution Pipes

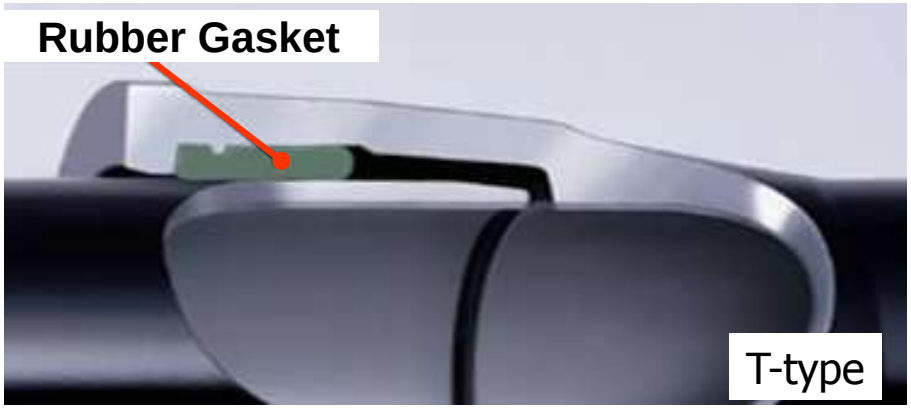
- Identify pipe materials and joint types that provide adequate seismic resistance
- Identify critical/important distribution pipes
- Replace critical pipes based on seismic risk and in collaboration with the Asset Management and Pipe Replacement Programs
- Recognize earthquake damages and water service outages will occur
  - entire network cannot be cost-effectively replaced in near term
- Develop plan to ensure water service restorations achieve community resilience within an acceptable timeframe
  - Focus on most critical water restorations first
- Develop long-term network improvement program (e.g. 25 to 50 years)

Earthquake Resistant Ductile Iron Pipe

Comparison of Joint Structure

General Joint

(Flexible Joint)



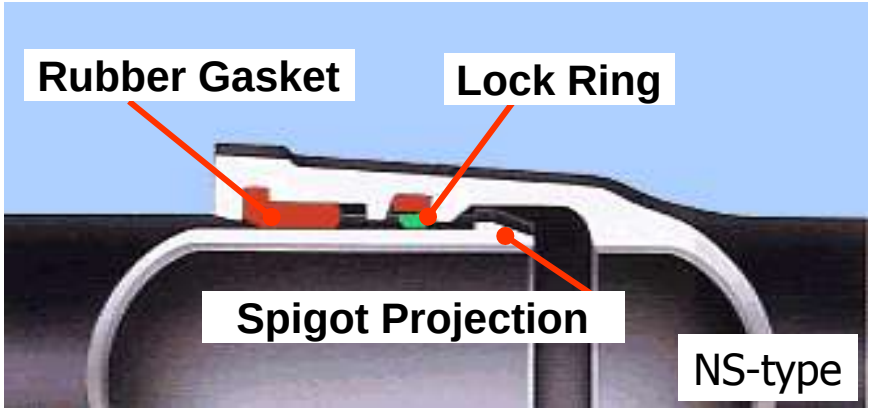
Expand

Deflect

No Expansion if lock joint used

Earthquake-Resistant Joint

(Chain structure Joint)



Expand / Contract

Deflect

Lock

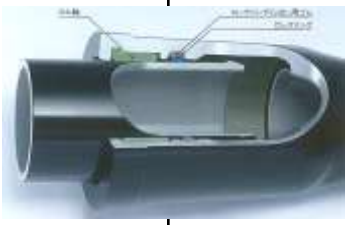
ERDIP Characteristics

Property	Performance	ISO 16134
Amount of expansion/contraction	±1% of L	Class S-1
Slip-out resistance	3D kN	Class A
Joint deflection angle	6－8° *1	

Note) **L** : Nominal pipe length (millimeters)
D : Nominal diameter of pipe (millimeters)
*1) Joint deflection angles depend on pipe diameters.

- **No Damage or Leaks** after 40-years of use
- Experienced many large Japanese earthquakes
- Subjected to several meters of permanent ground deformation

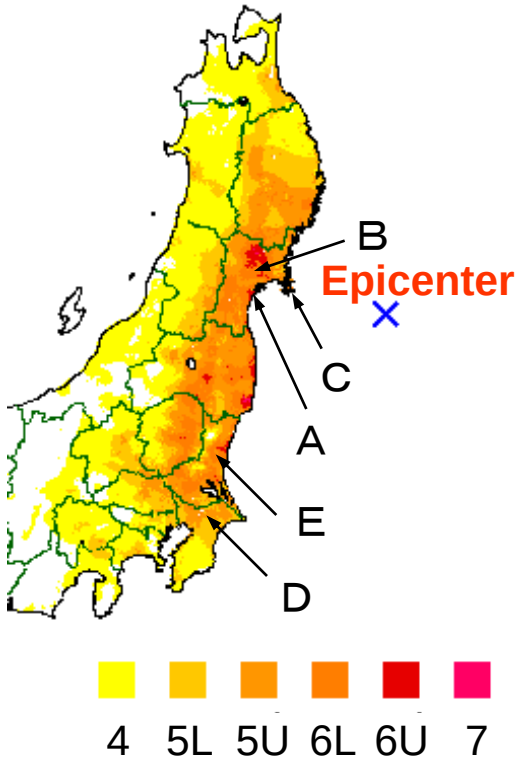
Diameter range of the earthquake resistant joints

Joint		Diameter Range (mm/inch) 75 (3”) 500 (20”) 1000 (39”) 1500 (59”) 2000 (79”) 2600 (102”)
Slip-on Type	GENEX	75～250mm (3”~10”) 
	NS	75～450mm (3”~18”) 
Mecha-nical Type	NS	500～1000mm (20”~30”/3.3’) 
	S	500～2600mm (20”~102”/8.5’) 

The 2011 Great East Japan Earthquake

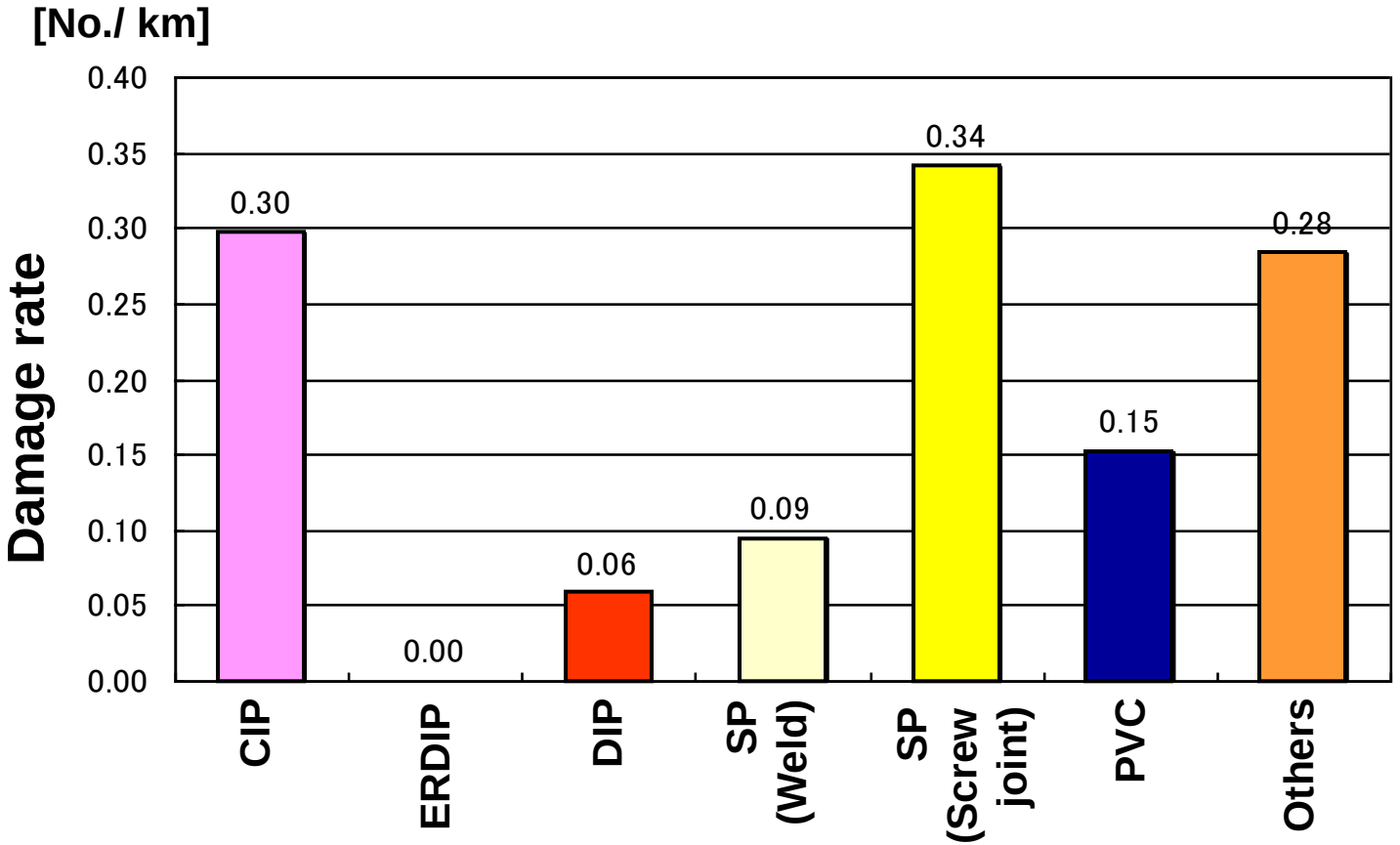
Overview of Damages on Water Pipelines

	Water works bureau	Water supply population	Maximum seismic intensity	Pipeline length (km)	Number of damages	Damage rate (/km)
A	Sendai City	1,017,407	6U	3,732	276	0.07
B	Miyagi Pref.	1,852,000 (water supply)	6U	333	35	0.11
C	Ishino-maki	200,025	6U	1,561	212	0.14
D	Chiba Pref.	2,928,062	6L	8,696	446	0.05
E	Mito City	264,133	6L	1,717	139	0.08



Seismic intensity in J.M.A. scale

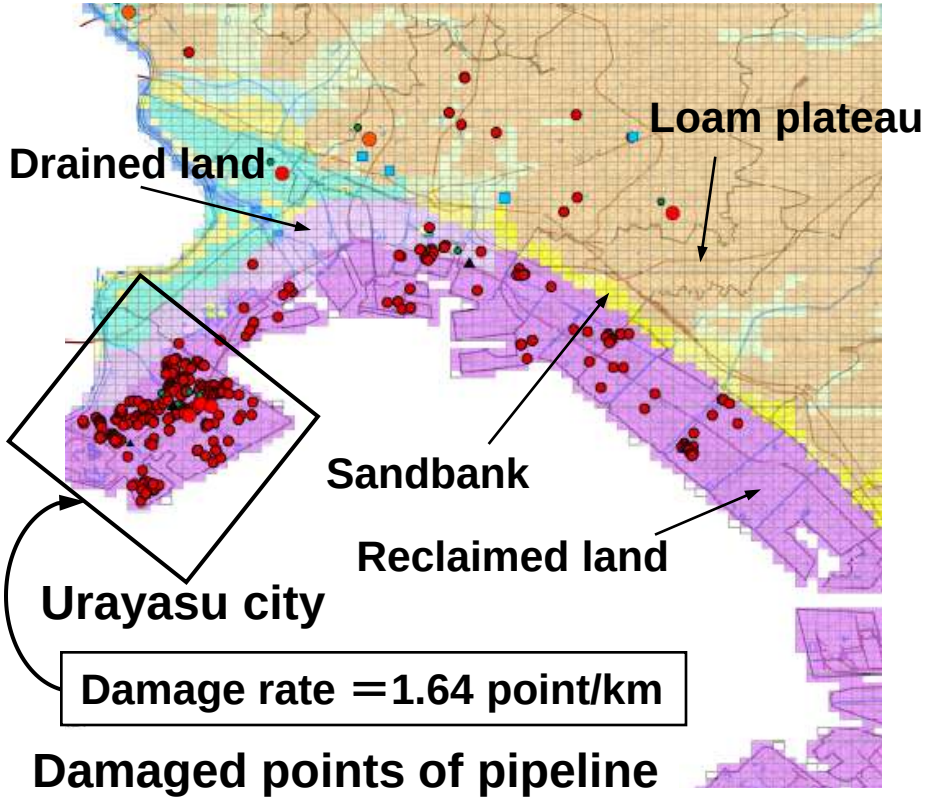
Pipe material comparison

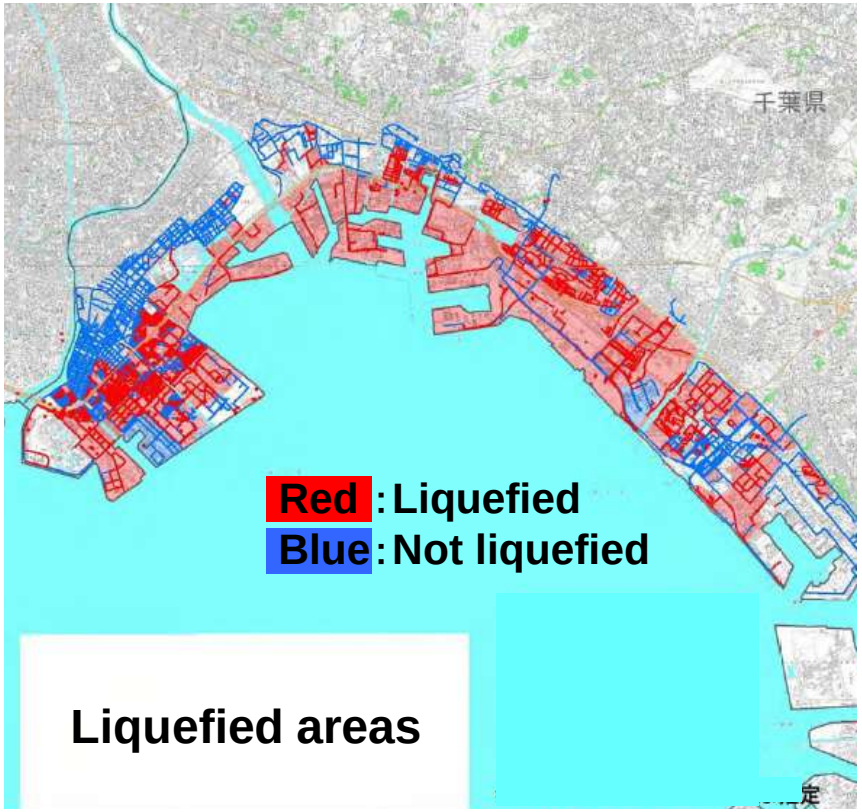


- **DIP is more reliable material than others.**
- **ERDIP suffered no damage the same as previous big earthquake.**

Damaged points and liquefied areas along Tokyo Bay

Many damages of pipelines occurred in the liquefied areas

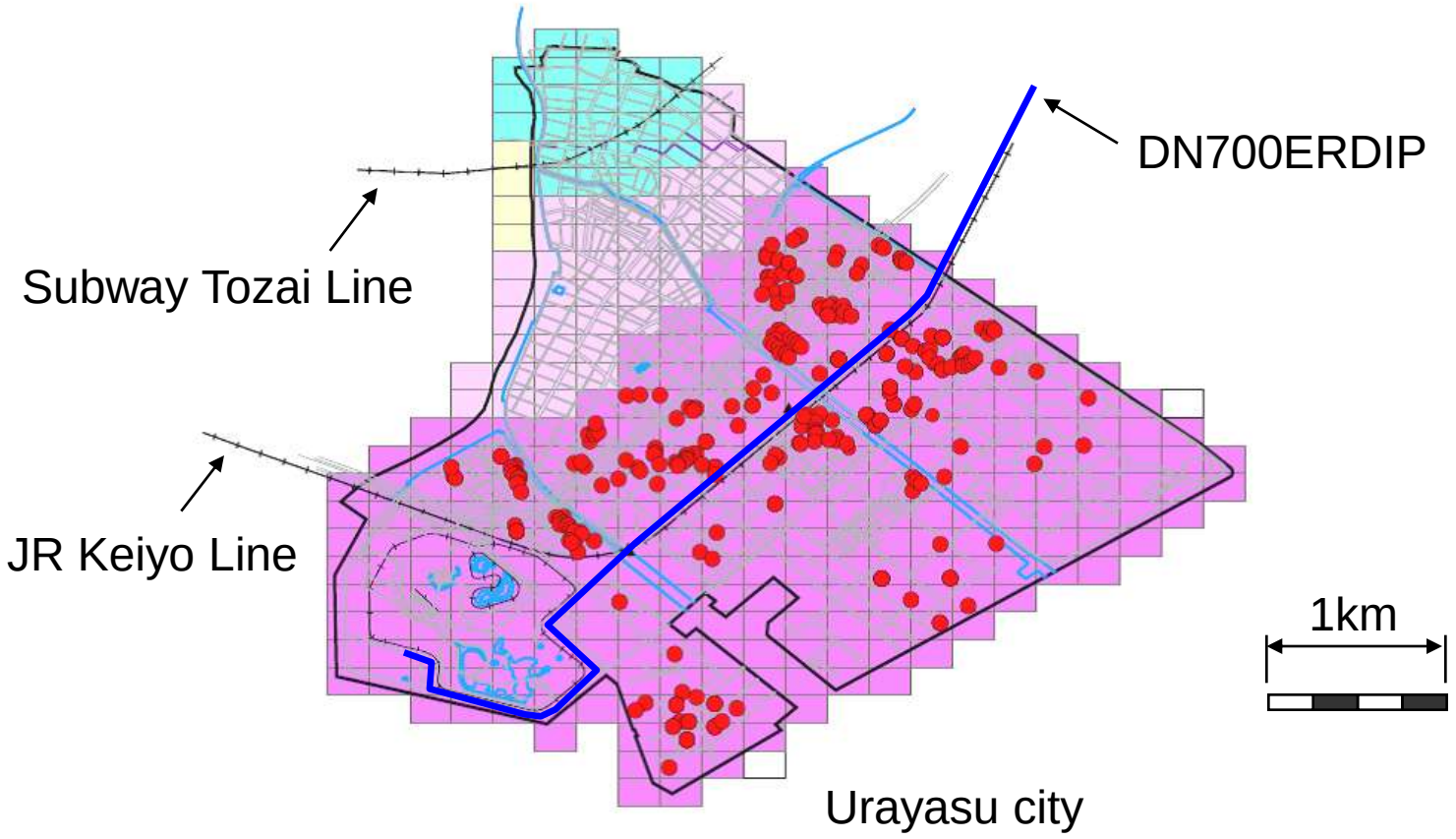




Source:
(Left drawing) map: Geospatial Information Authority of Japan.
Landform classification: National Research Institute for Earth Science and Disaster Prevention
(Right drawing) Ministry of Land, Infrastructure, Transport and Tourism, Regional Development Bureau

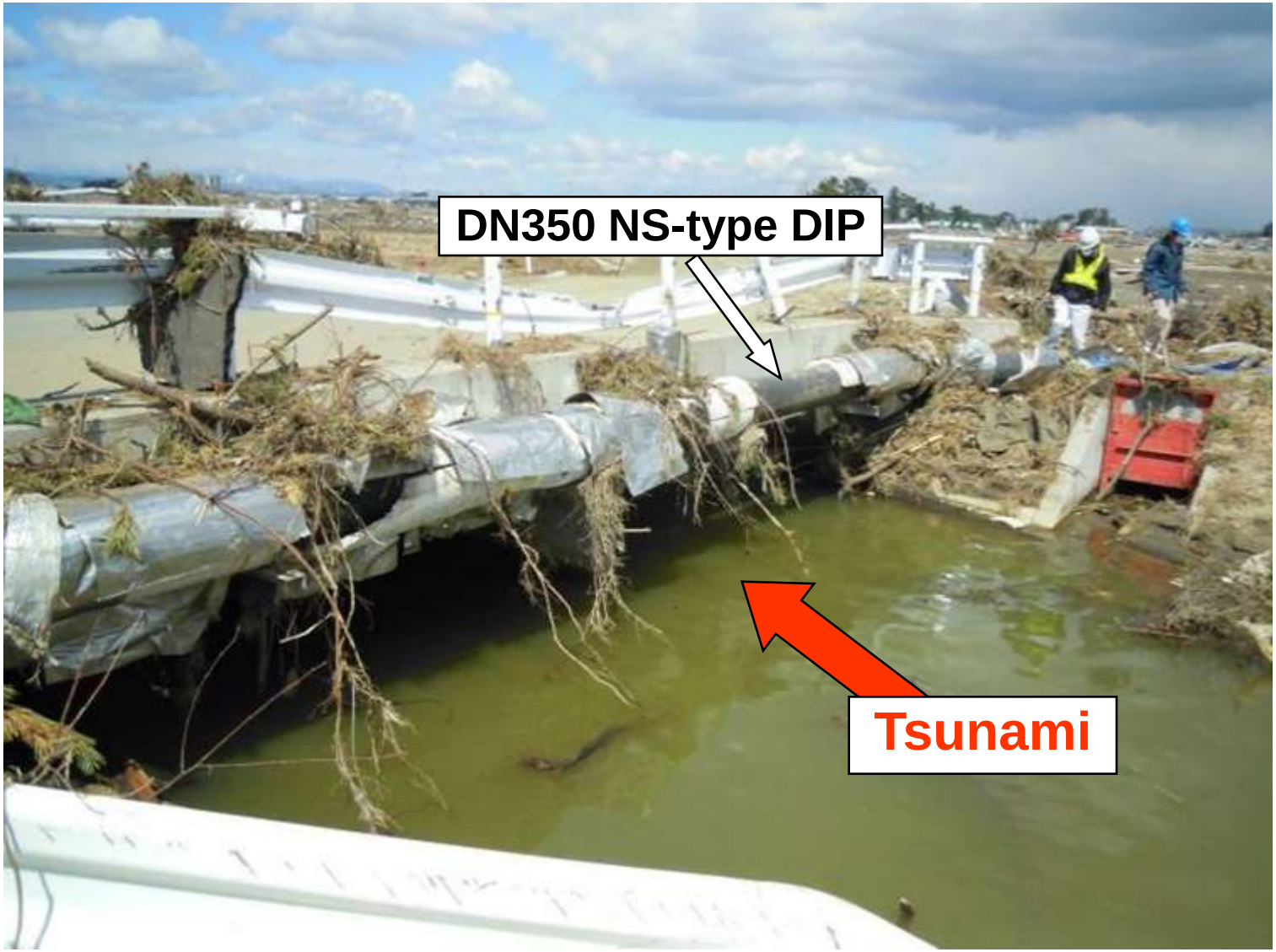
ERDIP suffered no damages in liquefied area

ERDIP suffered no damages in the liquefied areas where many damages occurred at water pipelines

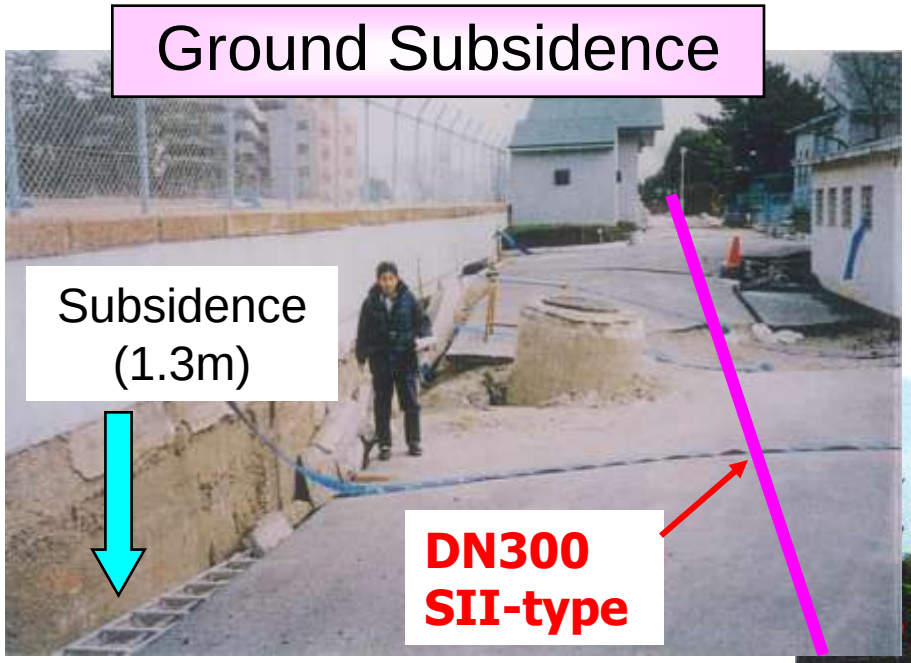


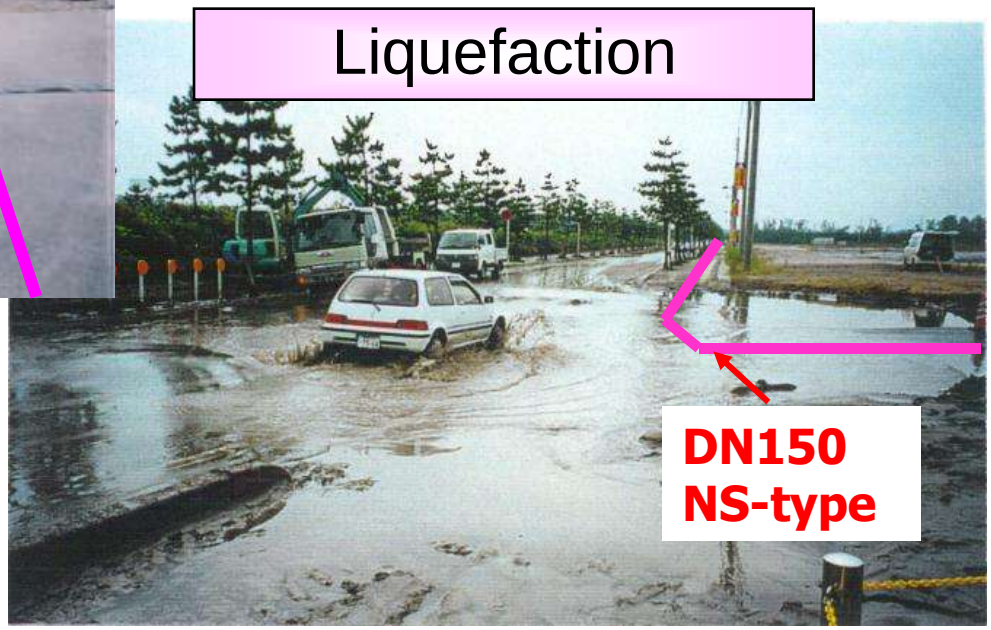
DN150, 200 NS-type (Landslide of Road by Tsunami)

DN350 NS-type DIP at Water Bridge



SII, NS-type DIP Withstand Large Ground Subsidence





SII, NS-type DIP withstand Landslide by typhoon

Landslide at Road

LADWP
Earthquake Resistant Joint
Ductile Iron Pipe
Pilot Project

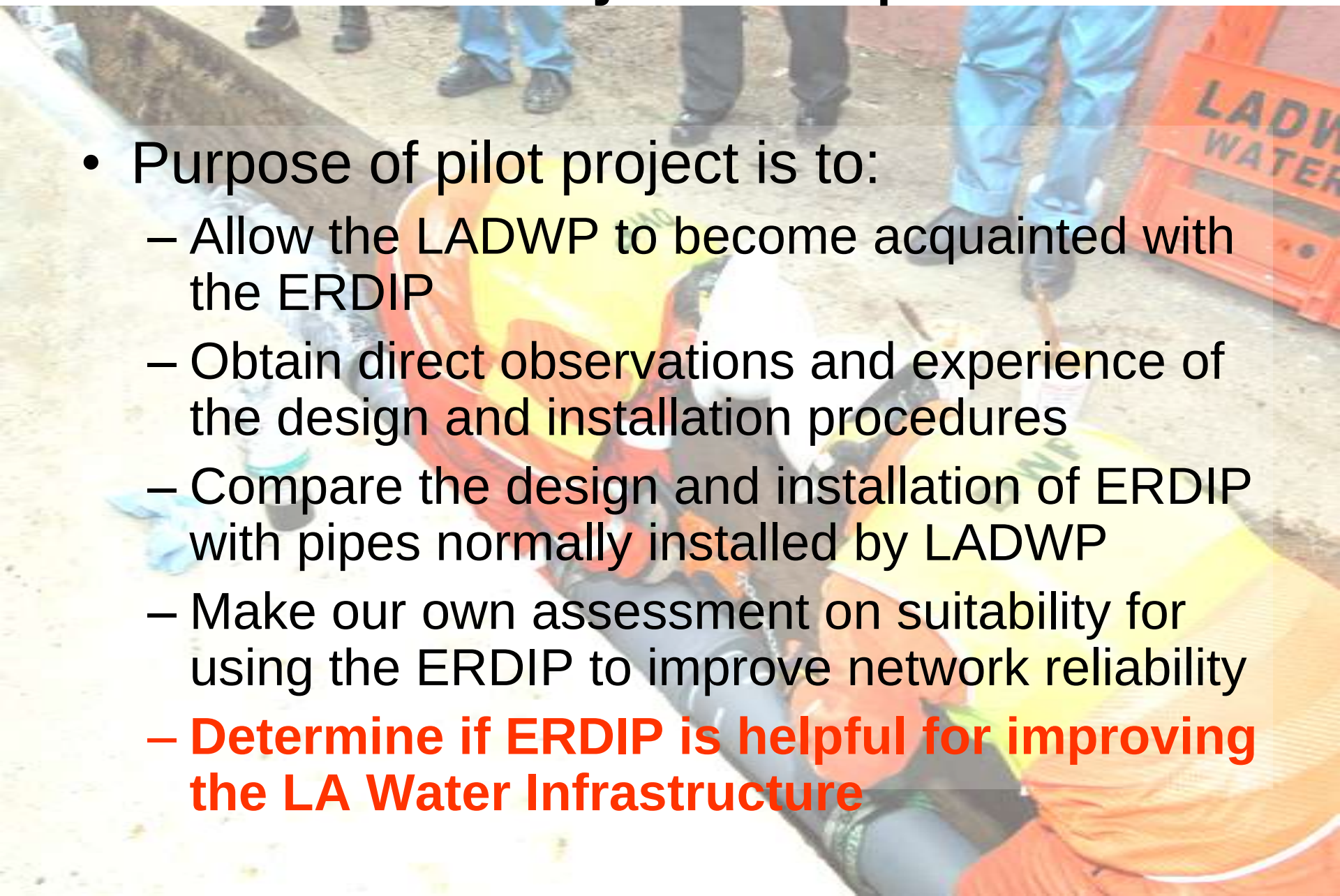
Training

Construction

Pilot Project using Earthquake Resistant **Joint** Ductile Iron Pipe (ERDIP)

- The ERDIP is 1 of several pipes that meets the proposed criteria for investigating use in LA for seismic resistance
  - Other pilot projects are being undertaken with HDPE and PVC
- Kubota and LADWP have collaborated to implement a pilot project to install ERDIP in Los Angeles
- Currently ERDIP only available and used in Japan
- LADWP is the 1st to use in USA
- Additional advantages (other than seismic)
  - Landslide risks
  - Erosion
  - Thermal stresses
  - Overall, the ERDIP may provide significant infrastructure reliability above the seismic risk

Pilot Project Purpose



- Purpose of pilot project is to:
  - Allow the LADWP to become acquainted with the ERDIP
  - Obtain direct observations and experience of the design and installation procedures
  - Compare the design and installation of ERDIP with pipes normally installed by LADWP
  - Make our own assessment on suitability for using the ERDIP to improve network reliability
  - **Determine if ERDIP is helpful for improving the LA Water Infrastructure**

Pilot Project Outline

We are here
For Reseda Blvd.

We are here
For Contour Dr.

(1) Presentation

1) Kubota sends pipes from Japan.
2) Kubota gives a presentation and demonstration on ERDIP (NS and GENEX models) pipe in Los Angeles.

(2) Develop the pilot project plan

In process for 3 more sites

1) LADWP settles the details of the pilot project (pipe diameter, length, schedule, etc).
2) LADWP's management approves the project plan.

(3) Preparation for installation

1) Kubota supports the pipeline design phase with training and reviews.
2) Kubota makes installation manual, and helps to addresses items needed to meet local requirements.
3) Agreement of purchase conditions between LADWP and Kubota.

(4) Production and Export (from Kubota)

1) Kubota produces pipe.
2) Export and transport (logistic, stock yard, etc).
3) Procure the fittings for joints between JWWA[1] pipe and AWWA[1] pipe standards.

(5) Construction

1) Kubota dispatches the pipe installation instructors from Japan.
2) Kubota provides training for field crews appointed by LADWP.
3) LADWP undertakes construction using their own field crews.

(6) Feedback

1) LADWP compiles the evaluation (design, construction, cost, etc).
2) Kubota improves NS and GENEX for US market, (if necessary).

(7) Present Results

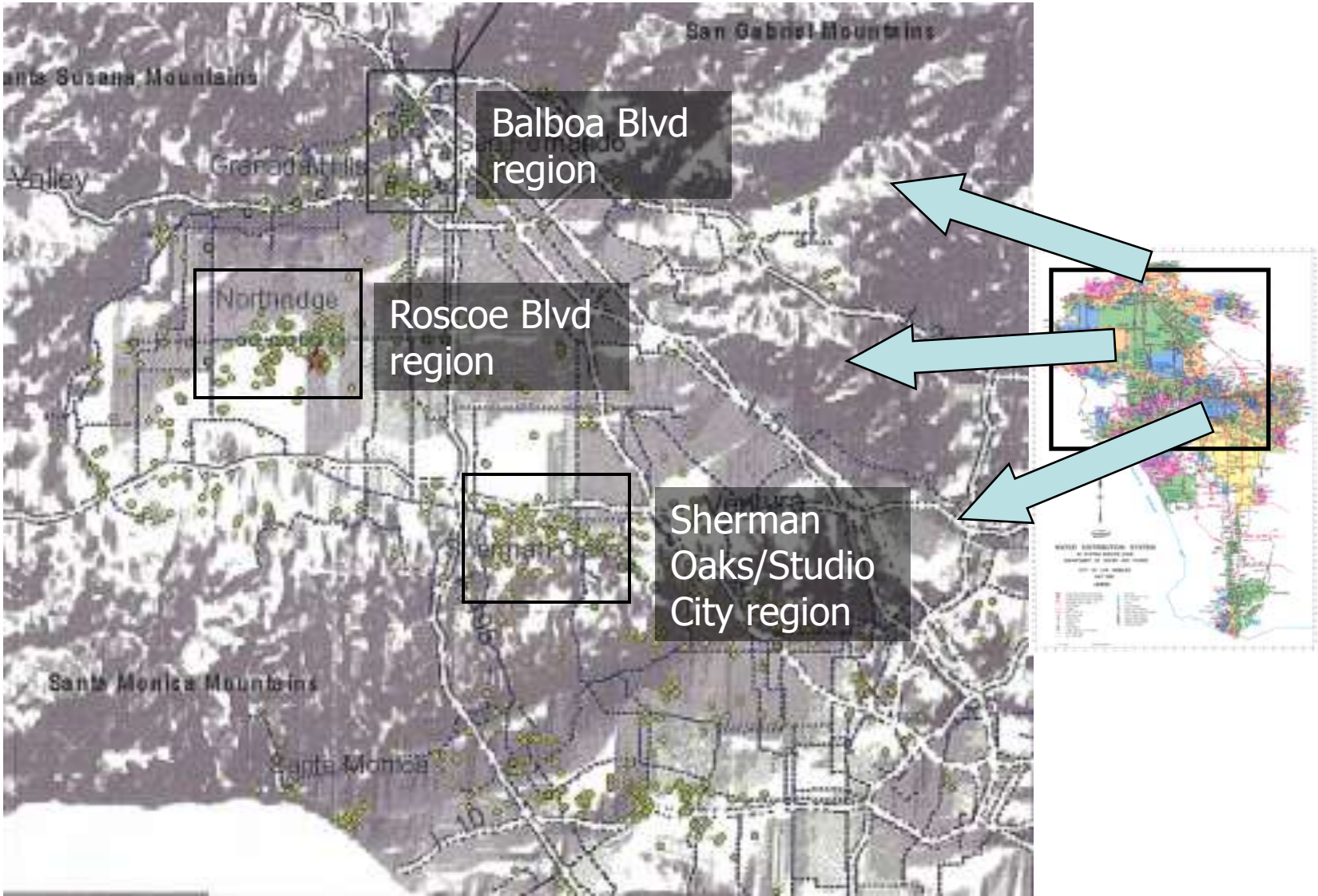
1) LADWP announces the achievement of pilot project.

[1]Japan Water Works Association
[2]American Water Works Association

Pilot Project Site Selection

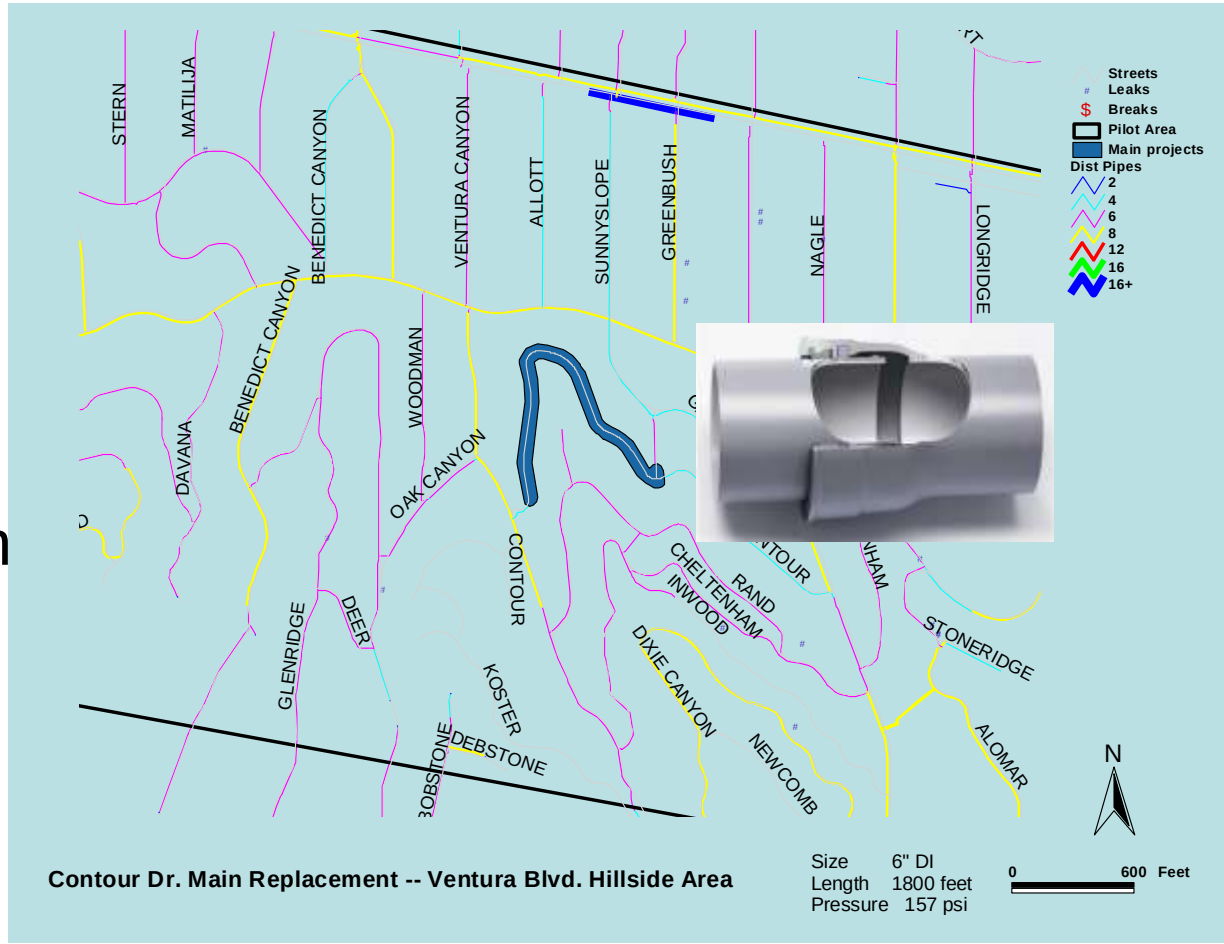
- **For 1st two sites**: Identify areas damaged by ground failure during the 1994 Northridge Earthquake
  - Balboa Blvd
  - Reseda Blvd Region
  - Studio City/Sherman Oaks Region
- Review pipe layout
- Compare with planned pipe replacements
- Select pipes to be replaced as part of pilot project
- Implement pilot project in a manner consistent with a long-term seismic improvement program.
- Currently have two pilot sites
  - Reseda Blvd. (Relatively level ground in San Fernando Valley)
  - Contour Drive (Sloped and curvy roads in Studio City)
- Select **additional** pilot project **sites** using **resilience criteria**
  - West LA
  - Central LA
  - Harbor

Pilot Project Locations Considered



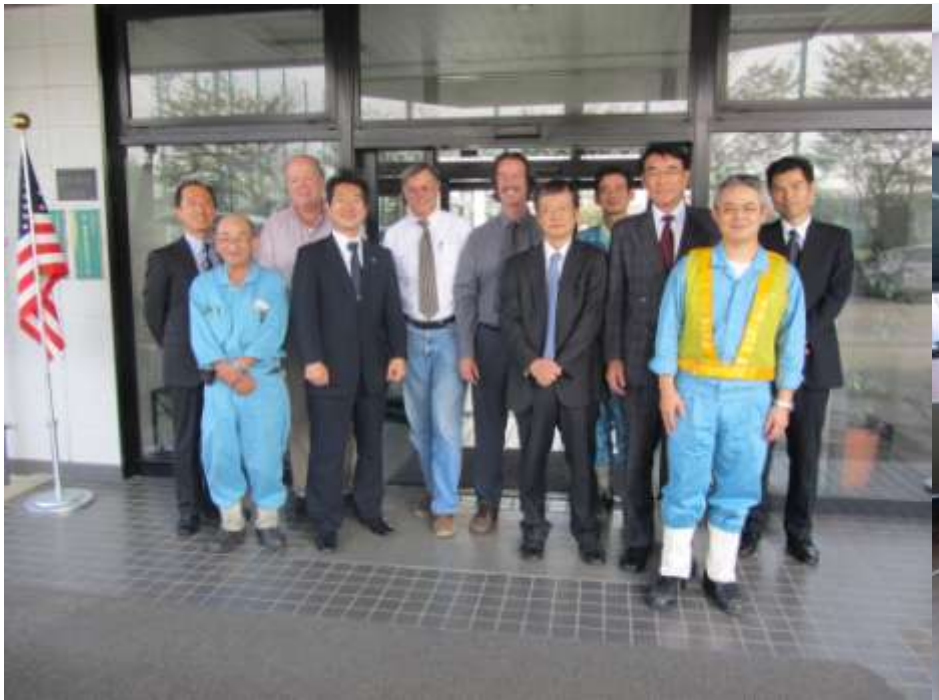
Main Replacement Contour Drive

- LADWP originally planed to replace ~1750’ of 6” line;
- 157 psi (1.1 Mpa)
- Proposed pilot to include ERJDIP
- Training performed 1/15 to 1/18/13
- Initiated Construction on 1/28/13
- 1752’ installed
- ERDIP installation completed on April 30, 2013 (53 work days)



Steps Taken to Implement Pilot Project

- Learned about ERDIP over past decade
- Met with Kubota Corp. (Mr. Toshima) in October 2011
  - Identified opportunity for pilot project
- Concept encouraged by LADWP managers



Kubota ERDIP Presentation and Demonstration

- LADWP-Kubota meetings held in LA on January 23-25, 2012
- Presentation and demonstration held in Los Angeles on January 24, 2012
  - Invited guests from waterworks community
  - Over 110 attended from 17 organizations
  - Support from WRF
- Demonstration allowed LADWP hands-on learning experience with GENEX
  - Positive feedback

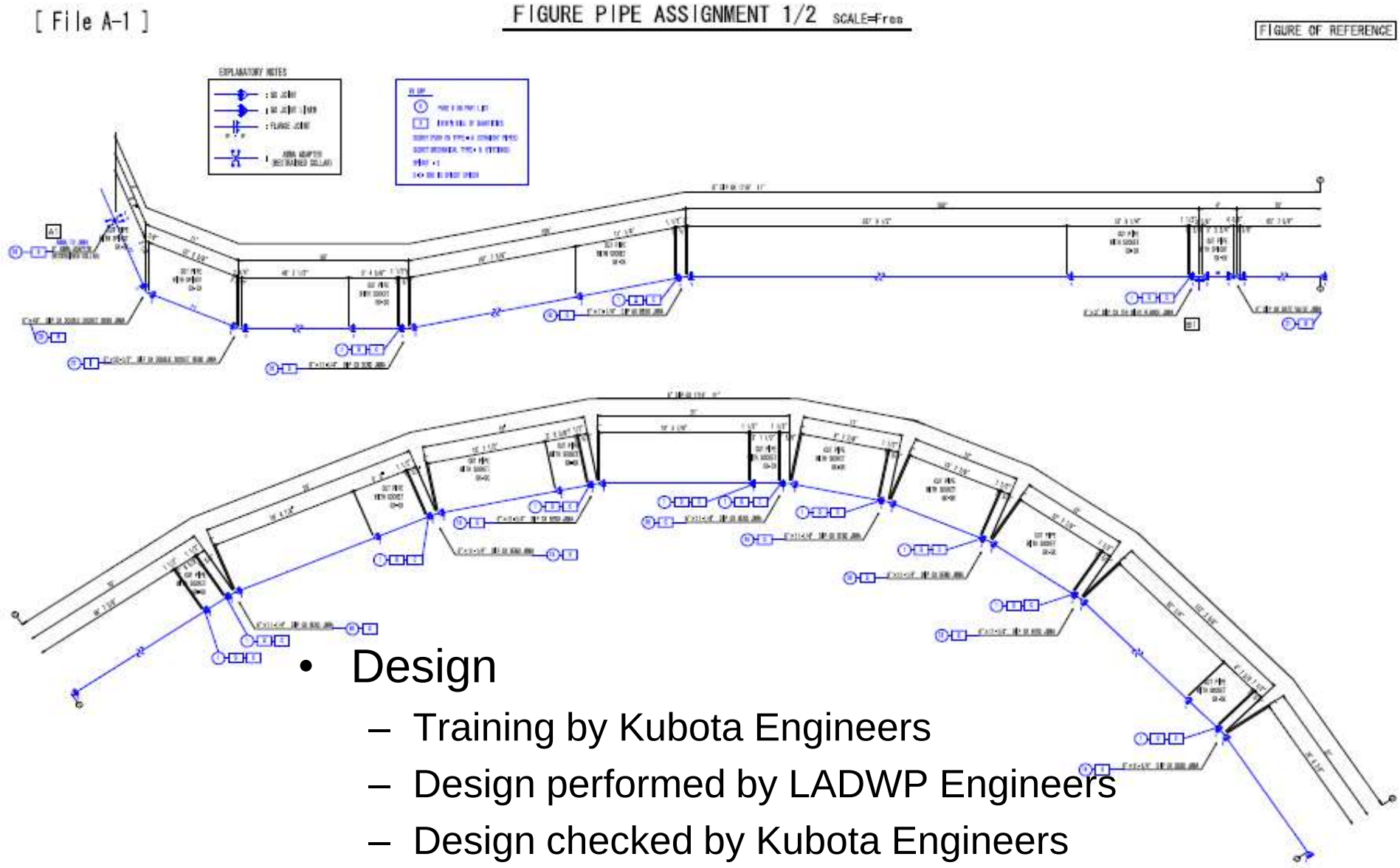

LADWP crews demonstrating GENEX Pipe assembly


LADWP-Kubota team


Mr. Hara, Kubota Engineer

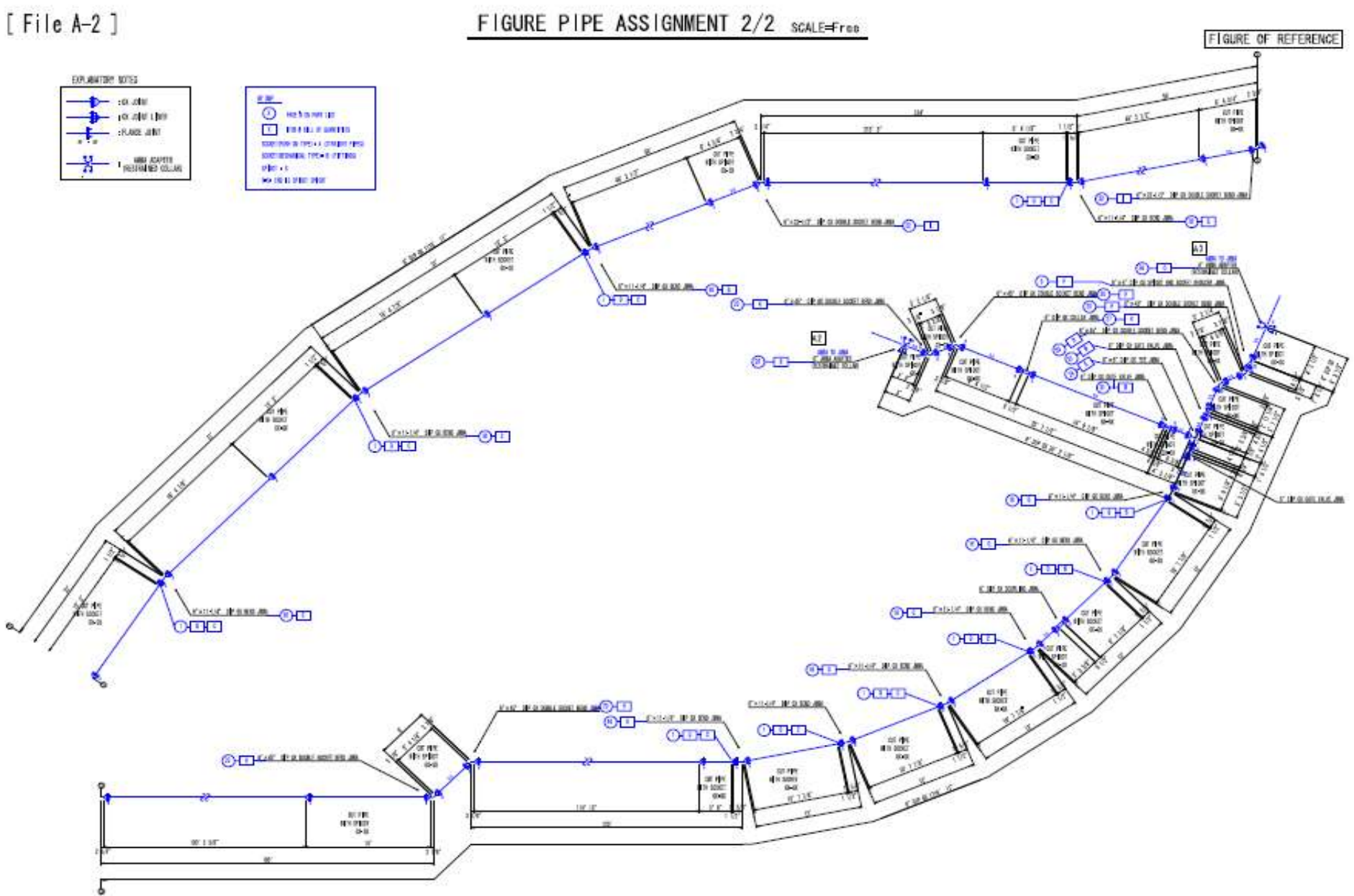

Mr. Toshima, Kubota Manager

Pipe Design, Contour Drive



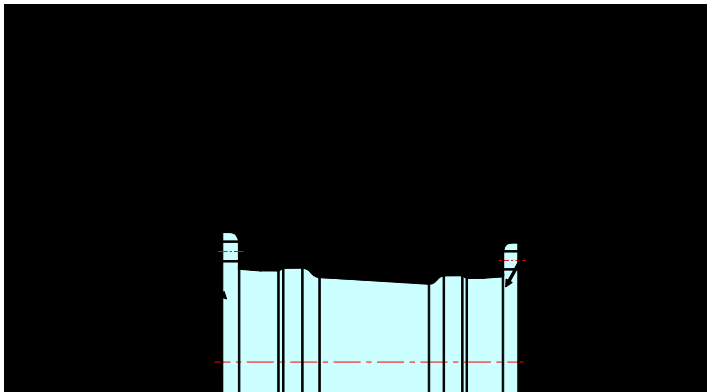
- Design
  - Training by Kubota Engineers
  - Design performed by LADWP Engineers
  - Design checked by Kubota Engineers

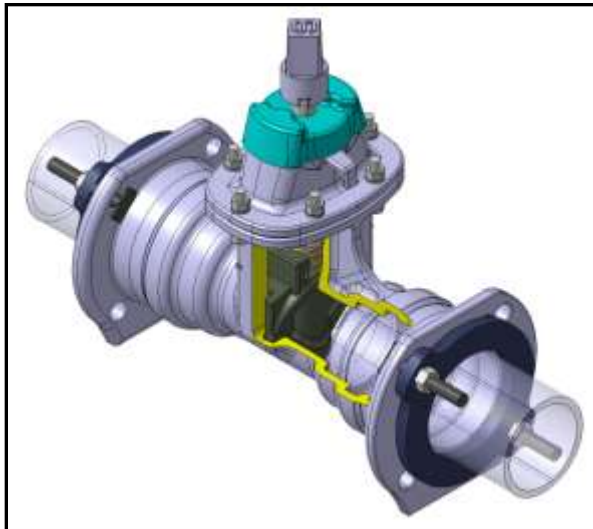
Pipe Design, Contour Drive



Steps Taken to Implement Pilot Project

- Worked with Kubota on:
  - Pipe layout plans and design changes
  - AWWA to JWWA adaptors
  - Installation procedures
  - Specifications
  - Backfill requirements (sand vs cement slurry)
- Worked closely by email
- Follow up meetings held in LA on:
  - August 7, 2012
  - October 17, 2012





Procurement and Delivery

- Procurement
  - Informal contract (>$150,000)
  - Sole source
  - Ordered extra materials for:
    - Training
    - Field alterations
- Delivery in December, 2012

ORIGINAL PURCHASE ORDER

DEPARTMENT OF WATER AND POWER

CITY OF LOS ANGELES

P.O. BOX 51111, ROOM 1114, LOS ANGELES, CA 90051-0100

ITEM NO.	QTY / UOM	DESCRIPTION	UNIT PRICE
4	2 EACH	NAICS: 423840 MATL CODE: 9494990 EA PEQTY 2 SPIGOT & SOCKET REDUCER, JOINT = GENEX SIXE (MM) = 150 X 100	$216.00 EACH
5	28 EACH	NAICS: 423840 MATL CODE: 9494990 EA PEQTY 28 BEND, JOINT = GENEX SIZE (MM) = 150 (DIA.) X 11 1/4 DEGREES	$271.00 EACH
6	13 EACH	NAICS: 423840 MATL CODE: 9494990 EA PEQTY 13 DOUBLE SOCKET BEND, JOINT = GENEX SIZE (MM) = 150 (DIA.) X 45 DEGREES	$411.00 EACH
7	7 EACH	NAICS: 423840 MATL CODE: 9494990 EA PEQTY 7 DOUBLE SOCKET BEND, JOINT = GENEX SIZE (MM) = 150 (DIA.) X 22 1/2 DEGREES	$375.00 EACH
8	2 EACH	NAICS: 423840 MATL CODE: 9494990 EA PEQTY 2 SPIGOT PIPE WITH FLANGE, JOINT = GENEX SIZE (MM) = 150	$164.00 EACH
9	4 EACH	NAICS: 423840 MATL CODE: 9494990 EA PEQTY 4 COLLAR, JOINT = GENEX SIZE (MM) = 150	$445.00 EACH
10	2 EACH	NAICS: 423840 MATL CODE: 9494990 EA PEQTY 2 DOUBLE SOCKET SHORT PIPE, JOINT = GENEX SIZE (MM) = 150	$354.00 EACH
11	6 EACH	NAICS: 423840 MATL CODE: 9494990 EA PEQTY 6 RESILIENT SEATED GATE VALVE, JOINT = GENEX SIZE (MM) = 150	$894.00 EACH

Technology Exchange

- LADWP traveled to Japan Nov. 2012
  - Engineer
  - Distribution Manager
  - Field/Training Supervisor
- Meet with:
  - Kobe Waterworks Bureau
  - Sendai Waterworks Bureau
  - Kyoto University

- Direct exchange of information at equal levels
- See earthquake damages and pipe performances
- Observe ERDIP installation by Japanese
- Visit Kubota manufacturing plant for ERDIP

Cultural Exchange


Sendai Beef


Nanzen Temple, Kyoto


Sendai


Sushi

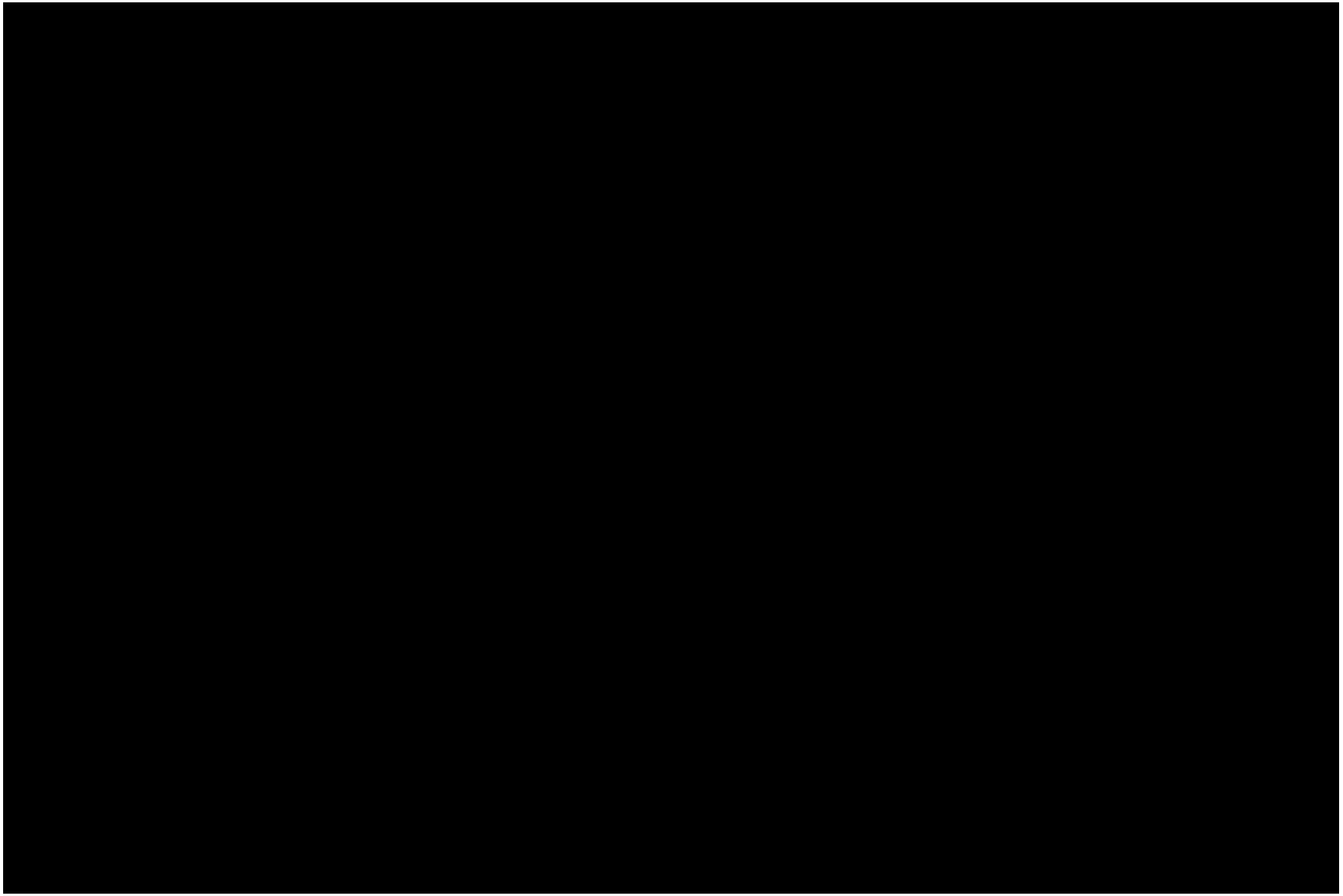
Cultural Exchange


Kobe Beef


Kobe elementary school, emergency evacuation center

Training and Installation in LA

LADWP Installation Video



Acceptance Criteria

Contour Drive

Near-term criteria

Item	Criteria	Status as of July 1, 2013
1	Acceptance of Concept	Achieved
2	Application to network resilience	Able to meet concept outline
3	Ability to learn about the technology application	Achieved, January 2012
4	Ability to perform engineering design for ERDIP	Achieved by LADWP staff
5	Ability to purchase pipe	Achieved Fall 2012
6	Ability to train and certify installation crews for ERDIP	Achieved January 2013
7	Ability to adopt local installation procedures to the ERDIP technology (e.g., slurry trench fill)	Achieved, Summer 2012
8	Field crew ability to install correctly	Achieved, Feb./March 2013
9	Positive acceptance from LADWP Distribution Division (Management and supervisor levels)	Achieved, management, supervision, and const. crews interviewed May 9, 2013.
10	Installation rate (feet per day)	Acceptable, similar compared to other similar projects.
11	Project cost in comparison with other pipe projects (standard DIP, steel, nonmetallic, etc.)	Acceptable, within an acceptable range at pilot stage.
12	Workability (the degree of ease the material can be cut, shaped or smoothed by hand or machines and capable of being put into effective operation)	Acceptable and overall positive input from field crews.

Long-term Criteria:

1. Investigation corrosion resistance of GenEx coating
2. Actual seismic performance*

*Seismic performance is not a criterion for accepting use of this pipe on a full scale production level. We must accept the documented positive performance in Japan of no breaks or leaks for nearly 40 years.

PILOT PROJECT RESULTS
CONTOUR DRIVE

- Costs
  - Construction: 8% to 13% increase, mostly from material cost.
  - Engineering: cost about doubled, increased total project cost by ~7%.
  - Project: 15% to 20% total project cost increase.
- Workability
  - Construction crews found the material to be very workable, in some cases easier than the Tyton joint pipe normally placed by the LADWP
  - The tools are very good, easy to use, and helped make installation go smoothly. Smooth Process:
    - **Removed straining and as a result eliminated injuries that otherwise can occur when forcing the pipe spigot into the bell, &**
    - **Prevented rolling the gaskets out of the bell**.

LADWP Outreach

- Purpose:
  - provide others an opportunity to learn from the LADWP pilot project while it was being undertaken
  - educate other water agencies, associations, universities, and consulting firms about the ERDIP in case it may be useful for them
- Demonstration project, January 2012
  - Over 100 participants from LADWP, other agencies, consultants, and Universities
- Site Visits, February and March 2013
  - 7 site tours
  - Attendees included 60 people from 17 organizations (not including LADWP or Kubota)

Site Visit Outline

- 10:00AM 1.5-hour presentation covering:
  - Background and purpose for using the ERJ-DIP, and
  - Plan and purpose of the LADWP Pilot Project
  - Questions and Answers
- 11:30 PM Lunch in cafeteria (on your own)
- 12:15 PM Take LADWP vans to the site
- 1:00 PM View placing and jointing the pipe.
  - Communication with LADWP installation supervisor.
- 2 to 2:30 Depart site and return to JFB.
  - End of meeting.

Media Attention

- Los Angeles ERDIP Pilot project has captured attention of international media
- 9 News Paper articles
  - 7 in Japan
  - 2 in USA (LA Daily News & Wall Street Journal)
- 7 Television broadcasts
  - 3 in Japan
  - 1 in San Francisco (KTVU)
  - 3 International (NHK World)

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Los Angeles Tests Water Pipes That Stand Up to Quakes

By Hannah Karp

Los Angeles has a come up with a strategy to prepare for the Big One: earthquake-proof water pipes made only in Japan.

The Los Angeles Department of Water and Power recently finished installing a test patch of about 2,000 feet of a special kind of iron piping in the San Fernando Valley.

The piping, made by Japan's Kubota Corp. and designed to withstand ground deformation, has endured 40 years of earthquakes in Japan—including the 9.0-magnitude Tohoku earthquake that struck in 2011, triggering a tsunami.

Unlike traditional water pipes, these so-called ductile iron pipes are able to withstand quakes because they can bend and flex instead of buckling under pressure. The system is engineered to work like a chain, meaning it doesn't break apart even if its various components are moving.

Engineer Craig Davis is overseeing a test of Japanese-made earthquake-resistant water pipes in Los Angeles.

LADWP supervising engineer Craig Davis learned about the pipes in 2003 and negotiated to import some for the Los Angeles pilot project shortly after the 2011 quake. Mr. Davis and water agencies in San Francisco, Portland and Seattle have contacted him, expressing interest in similar projects. "We're just learning about it—it's really only recently that you could identify this pipe system as earthquake-resistant," said Mr. Davis, who sent his chief work-crew trainer to Japan last year and has two Japanese reps on site supervising the Los Angeles installation.

Initially, the city plans to replace only a fraction of its piping—about 3 miles of the total 7,000 miles—with the quake-proof tubes, limiting installation to the most vulnerable, fault line-adjacent areas. The material is expensive, about 2½ times the price of the standard water pipe used in Los Angeles.

The first test installation cost $104,000; the 6,500 feet of piping for the second installation scheduled to start this fall will cost $900,000. To cut expenses, Los Angeles officials are trying to help Kubota find a manufacturing partner in the U.S.

The Los Angeles Aqueduct, which channels water to Southern California residents from the Sierra Nevada more than 200 miles away, was built a century ago, and the city has worked to replace and retrofit the system's oldest cast-iron pipes in recent years. LADWP said it has installed 2,290 miles of new pipe since 1963 and replaced 107 miles of pipe since 2006.

But work crews have struggled to keep pace with water-main bursts throughout the city. Engineers say bursts may have intensified since rules went into effect limiting outdoor plant watering to certain times during the week, meaning more people are watering at the same time, causing increased pressure.

The Japanese quake-proof piping has endured forces like shaking, landslides and extreme temperature swings because it can expand, contract and bend without leaking or pulling apart, said Thomas O'Rourke, an engineering professor at Cornell University who studies such pipes. The flexible joints are still strong enough when they lock up to allow a heavy load of water to flow through the piping.

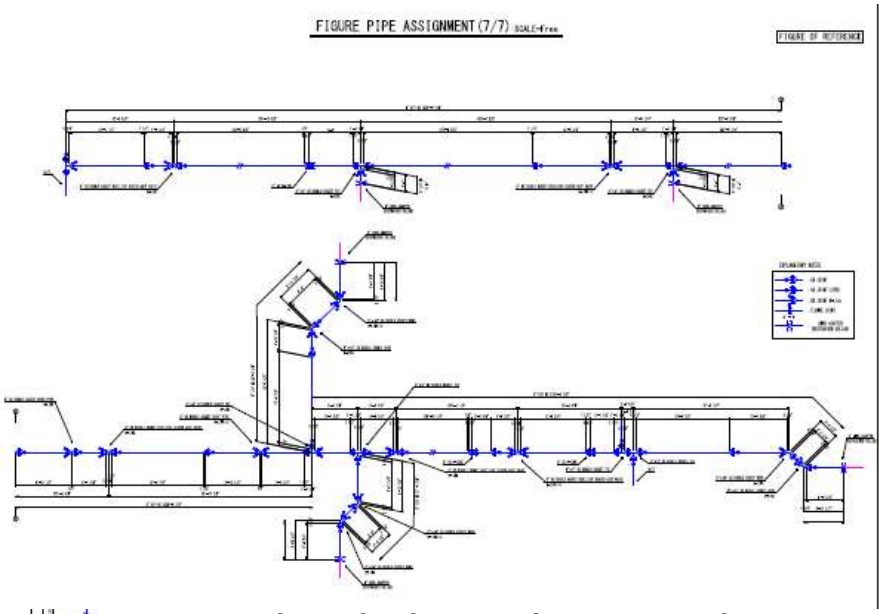
While some U.S. manufacturers also produce ductile iron pipe, those varieties haven't been designed with quakes in mind, nor have they been tested through nearly as many tremors as in Japan, Mr. O'Rourke said.

Meanwhile, the LADWP is adopting a different kind of plastic-piping technology used in New Zealand to protect Los Angeles's water supply as it crosses the San Andreas fault through a tunnel on its way to the city. Although continuous plastic pipes couldn't be easily integrated into most of the city's cast-iron distribution system, the agency plans to route water through one long tube just as it passes through the Elizabeth Tunnel, which could easily cave in during a major quake. Construction is slated to begin in the fall on the $4 million project.

"This reduces significantly the risk of losing the water supply to Los Angeles, which would be a real threat to the U.S., not just to Southern California," Mr. O'Rourke said.

In 1994, the 6.7-magnitude Northridge earthquake cost Los Angeles more than $460 million in pipe, tank and filtration-plant repairs, according to the LADWP. It took seven days to get water flowing to all its customers.

Pilot Project Status
Other sites



Reseda Blvd. Design Drawings

- Reseda Blvd.
  - ERDIP Design in progress
  - Phase I in progress
    - Installing 1st line of standard DIP
  - Material Procurement method
    - Formal (present to Board of W&P Commissioners)
  - Construction planned to initiate around July 2014
- Western, Central, Harbor
  - In the process of selecting sites for design

Summary

- Kubota ERDIP is one of several potential pipes that can help improve the LADWP distribution network seismic performance
- Pilot project provides:
  - Direct experiences to determine applicability of new technologies into the network
  - Opportunity to apply seismic improvement concepts into the distribution network
  - Incremental seismic improvements
- Distribution network seismic improvements are important for LADWP infrastructure reliability
- **Pilot Project results are positive** so far

Questions?